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Problems and Prospects of the Triticale Option for Kenya

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Executive Summary

Background

Triticale was introduced into Kenya in 1967. Since then its production has been promoted to supplement wheat in low potential areas where conditions are marginal for wheat production. Triticale has been regarded as a potential solution to Kenya's rapidly growing dependence on wheat imports; hence, several research advancements have been made and important changes in crops' pricing and marketing policies took place.

However, despite these efforts, no reliable data exist on farmers' acceptance and adoption of triticale, nor on its acreage, total supply and use. No surveys have been conducted in order to establish an information base for assessing problems and prospects of triticale production and utilization in the country. Statistics cited for area and production often disagree by a substantial margin.

Therefore, this research was initiated to contribute towards filling the information gap in the triticale sub-sector and examining the problems and prospects of its supply and utilization. In addition to updating published statistics and knowledge about triticale, the results of the analysis will have important implications for triticale research and policy-making in Kenya, and help CIMMYT assess the success and future of its triticale research program from a global perspective.

Results

Data were collected from surveys done of triticale farmers, seed suppliers, researchers, policy-makers, the cereals marketing board and a group of millers over two seasons, 1990 and 1991. Complete coverage of triticale farmers was attempted during the 1991 survey to the best knowledge of local farmers' organizations, extension officers, seed suppliers, millers, researchers and marketing agents, who provided the names of triticale growers.

The major findings of the 1990 informal survey indicated that triticale was mainly sown by large-scale farmers, with T65 being the most commonly used variety of triticale. The majority of the surveyed farmers bought from other farmers or produced their own seed after the first acquisition from the Kenya Seed Company (KSC). All farmers followed the same practices on triticale as they did on wheat, but with less spraying of chemicals and average lower fertilizer levels. All agreed that under marginal conditions, triticale performs much better than wheat.

The majority of growers have accepted the price that is 85% of the wheat price but complained about the difficulties associated with dealing with the National Cereals and Produce Board (NCPB). Most important among these problems are: (1) the high handling and transportation costs due to delayed off-

loading and the long wait of trucks at the NCPB depots, which led to an estimated additional cost of 5% of the crop value over and above the actual transportation costs; (2) delayed payments for the delivered crop; and (3) reluctance of the NCPB to buy the crop in the first place.

All the farmers liked triticale and wanted to expand if adequate demand existed. On average, about 50% of total production was fed to animals by 40% of the growers. The area under triticale was estimated at 2500ha with an estimated production of 5000t. Most farmers did not have enough contact with the research and extension services, and while expressing strong interest in improved triticale seeds, they were not aware of new releases or did not find the seed. The small farmers thought that triticale was a crop for large farmers.

The formal survey investigating awareness indicated that 74% of the surveyed wheat farmers have never heard of triticale. A majority of the farmers who were aware of triticale did not adopt it for lack of adequate demand, low prices and unavailability of seeds.

The number of farmers growing triticale has increased from 21 (60%) in 1990 to 25 (70%) in 1991. Results of the 1991 survey showed that most of the surveyed farmers (86%) confirmed the yield advantage of triticale over wheat. Moreover, 77% of the farmers considered triticale to be superior to wheat in terms of tolerance to diseases, particularly rust, but only 57% experienced lower production costs with triticale. While most (86%) believed there was inadequate demand for triticale, all (100%) thought decontrolling triticale prices and adequate marketing will improve demand. Only 40%, however, found the price set by NCPB (15% lower than wheat) very low. The free market price of triticale was 90% of the wheat price in 1991, higher by 5% than the NCPB ratio used before 1991, indicating that decontrolling had improved the price. Only 5% of the farmers acquired seeds from KSC for the 1991 season; the area under triticale was estimated at 3000ha with an estimated production of 6600t.

Implications for Research and Policy

The fact that the majority of farmers, especially among small-scale growers, were not aware of triticale and had little contact with research indicates the importance of establishing more effective research-extension-farmer linkages for faster diffusion of agricultural innovations. On-farm research is also needed to make the generated technologies well suited and more acceptable to farmers. On the other hand, farmers who are aware of or grow triticale indicated that lack of adequate demand was the major reason for the slow growth, if not decline, in triticale production.

Millers, however, expressed a strong desire to increase purchases of the triticale grain by substantial proportions, but preferred to contract directly with producers. This is mainly because Kenya built excess milling capacity during the 1980s that lead to a significant drop in utilized capacity. Major milling

firms, such as Unga Ltd., which is currently operating at 55% capacity, indicated interest in blending more triticale with wheat to raise their operating capacity to economic levels, which would diminish the inadequate demand problem.

As triticale has been promoted mainly to substitute for wheat as a human food, breeding work on improving the milling and baking qualities of triticale is required to boost demand. This will of course entail allocating more resources to triticale breeding and on-farm research programs. Research into adjusted baking technologies that would contribute to improved dough and bread qualities is also required together with wider consumer acceptance tests and surveys.

In addition to lack of awareness and insufficient demand, unavailability of seeds was found to be another important barrier to increased triticale production. Therefore, KSC will need to allocate more resources to multiplication of sufficient supplies of triticale seeds and diversify its varietal selection to types other than T65. Research could also contribute to alleviating shortages of seed in the short-run by undertaking more seed multiplication. Adjustments in seed certification standards may be required to establish lower size and germination rate requirements for triticale than those for wheat to increase the share of seed accepted from farmers' production contracted by the seed company. Demand for seed, however, is derived from the final demand for triticale, and hence is highly influenced by movements in the grain price and marketing arrangements.

On the other hand, the triticale option needs to be evaluated against other alternatives such as mixing sorghum flour for bread making. The comparative advantage of triticale, therefore, needs to be carefully examined against other options.

The fact that the yield advantage over wheat was alone not sufficient for triticale to take off during the past decade indicates the importance of the demand factor and the policy environment. While decontrolling the triticale market may stimulate high demand, it may not reveal the true economic potential of triticale if distortions in its close substitutes market, such as wheat, continue to exist. As wheat marketing and price are controlled, the price of triticale will remain effectively set to move in proportion to wheat.

Although about 50% of the triticale produced in Kenya was used to feed animals, the nutritive value of the common triticales and their potential for livestock feeding were not investigated and the crop was promoted mainly for human consumption. A study of the economic value of triticale as a substitute for other cereals as animal feed is thus required.

Problems and Prospects of the Triticale Option for Kenya

Introduction

Triticale (X. *Triticosecale* Wittmack) was developed as a new cereal in 1876 by a Scottish breeder, A.S. Wilson, from a cross between wheat (Triticum) and rye (Secale). The first fertile plant of triticale was obtained in 1888 by W. Rimpeau of Germany. It was not until 1938, however, that the Swedish breeder A. Muntzig was able to produce a large number of fully fertile hybrids using the colchicine treatment (Skovmand *et al.*, 1984). Discovery of colchicine was the key development that enabled breeders to overcome the infertility and artificial chromosome multiplication problems of the earlier releases of the man-made cereal, triticale.

Apart from sterility, other deficiencies have plagued earlier triticale lines. These varieties suffered, among other things, from grain shrivelling (low flour extraction ratio), pre-harvest sprouting, day length sensitivity, lodging, and poor baking and milling qualities. This cereal, however, was superior to its parent plants in other qualities such as nutritive value, tolerance to disease and better performance under marginal conditions, particularly drought and acid soils. Triticale was reported to have higher levels and a better balanced protein, and minerals, and produces larger volume biomass with higher concentration of phosphorus. These qualities made triticale an attractive substitute for other cereals in animal feed, which uses about 90% of the world's production of triticale (Skovmand *et al.*,1984; Varughese *et al.*,1987). On the other hand, its lower flour yield (grain shrivelling) with lower glutin content, slower mixing tolerance, higher Alpha-amylase, and shorter fermentation time discouraged its use for bread making (Amaya and Skovmand, 1985).

In 1968, CIMMYT breeders developed Armadillo, a cross between triticale and an unknown bread wheat. This reinforced interest in triticale and CIMMYT's research strategy then shifted towards developing triticale as a substitute for wheat in the more marginal growing environments. Triticale research in CIMMYT, however, emphasizes the potential for human consumption and thus continued to concentrate on improving the baking and milling qualities of the Armadillo triticale (Varughese *et al.* 1987, CIMMYT 1986). Significant improvements on the post-harvest qualities of the triticale grain were made but there is much yet to be done (see Table 1).

Motivation and Objectives

Kenya has promoted triticale production to supplement wheat in the low potential areas where conditions are marginal for wheat production (Ministry of Agriculture, 1981; Lijoodi, 1981). Since triticale was introduced into Kenya in 1967, several research advancements were made and important changes in the crops' pricing and marketing policies took place. Varieties with improved grain quality and higher tolerance to moisture stress, soil acidity and stem rust were released at the National Plant Breeding Research Center (NPBRC), Njoro. Adequate testing of post-harvest qualities of the released varieties showed acceptable milling and baking characteristics and suitability for bread making and home baking purposes (Oggema *et al.*, 1981; Kingma *et al.*, 1981). The marketing of the crop was controlled by the NCPB until 1990, when it was left to

free market forces. Until 1990, millers were not allowed to contract directly with farmers; by law, others were supposed to buy from NCPB and pay a commission.

Table 1. Improving Post-harvest Qualities of Advanced Triticale lines at CIMMYT, between 1971 and 1980

	International Triticale Screening Nursery (ITSN)			
	Early 1971	9th (1978)	10th (1979)	11th (1980)
Test weight (kg/hl)	60-71	51% above 75kg/hl	13% above 75kg/hl	12% above 75kg/hl
Flour yield (%)	50-65	15% above 68%	19% above 68%	30% above 68%
Flour protein (%)	6-11	-	-	-
Gluten strength (cc)	10-22	-	-	-
Loaf volume (cc)	355-360	35% above 600	70% above 600	77% above 600
Falling number (Alpha-amylase activity)	High gummy crumb in loaves	12% above 200	17% above 200	44% above 200

Source: Skovmand *et al.*, 1981

Several farmers and milling firms have produced and utilized triticale for various purposes, from animal feeding to bread making. Its area and production have accordingly fluctuated over the years. However, no reliable data exist on farmers' acceptance and adoption of triticale, nor on its acreage, total supply and use. Surveys have not been conducted to establish an information base for assessing problems and prospects of triticale production and utilization in the country. Statistics cited for area and production often disagree by a substantial margin. Therefore, this research intends to contribute towards filling the information gap in the triticale sub-sector and examining the problems and prospects of its supply and utilization. In addition to updating published statistics and knowledge about triticale, results of the analysis will have important implications for triticale research and policy-making in Kenya, and help CIMMYT assess the efforts of its triticale research program from a global perspective.

Triticale Research in Kenya

A plant breeder, L. Evans, introduced triticale into Kenya in 1967. The first lines, which came from Canada, together with materials from CIMMYT's International Triticale Screening Nursery (ITSN) were screened at the NPBRC in Njoro. In 1971 the NPBRC started the first triticale National Variety Trial (Wabwoto, 1981). The breeding strategy adopted by NPBRC was to develop triticales that are adapted to the Kenya environment, resistant to rust, and possess good grain qualities (Wabwoto, 1981).

A breeding program for triticale was followed, where selected lines are first tested on the station in the Triticale Preliminary Yield Trials (TPYT) before being advanced to the Triticale National Variety Trials (TNVT). Based mainly on yield, test weight and disease resistance, promising lines are selected at this stage for another year of screening under the TNVT at the following sites:

1. Molo, which is characterized by high altitude (2940 m.a.s.l.) and a high rainfall zone where there is a strong disease pressure and soil acidity.

2. Njoro, representing medium altitude (2240m.a.s.l.), medium rainfall, and neutral soils zone.

3. Uasin Gishu, a medium altitude, medium rainfall and very high soil acidity zone.

The best of these lines are then advanced to the Triticale National Performance Trials (TNPT). Selected lines go through wide adaptability testing during this stage for 2 or 3 years. The TNPT are conducted at 7 sites representing diverse growing conditions. Screened lines are either released for commercial production or recycled as parents if found superior, whereas poor performers are discarded. Pre-extension demonstrations are then carried out on the released varieties in farmers' fields, mainly in non-traditional wheat areas where conditions are marginal (NPBRC Annual Reports; Oggema *et al.*, 1981; Wabwoto, 1981).
Four triticale varieties (T14, T48, T50 and T65) were developed and recommended by the NPBRC for commercial use in February 1979. These varieties showed significant yield advantage on average, over the best bread and durum wheats grown at the time (Table 2)[1]. Research results and field testing indicated that triticale has consistently out-yielded other cereals under low rainfall and high soil acidity (Oggema *et al.*, 1981; Mulamula, 1981). While the released varieties had higher resistance to stem rust, they were found susceptible to Septoria, weed infestation, and storage pests as well as sprouting (Wabwoto, 1981). Moreover, the average hecto-liter (hl) weight and flour extraction rates of the released varieties were 65% and 60% respectively, compared to 75% and 72% averages for bread wheats (Mulamula, 1981).

Two other triticale varieties (T74 and T222) were recommended for commercial use by the NPBRC in 1982 and 1988 respectively. These two plus T65 are the only triticale varieties currently recommended (NPBRC, 1990). The earlier releases were dropped basically for breakdown of disease resistance or intolerance to drought stress. In other countries, such as Rwanda and Burundi, developmental work on triticale and commercial production has declined since 1986 as few lines proved resistant to the endemic races of stripe rust (Tanner and Mwangi, 1992). Over the past decade, however, triticale research at the NPBRC has been accorded lower priority compared to wheat and oil crops. In addition to the way resources are allocated to station activities, the sluggish growth in triticale production and use were the main reasons for a relatively lower priority in research. Factors related to triticale policies rather

[1]While we failed to trace any official record reporting the formal release of the six triticale varieties listed in Table 2, these varieties were cited in Ogemma *et al.* (1981) and appear in the variety recommendations lists produced by the NPBRC annually.

than its genetic and agronomic suitability were blamed for the slow pace of expansion in its production and demand, inspite of the strong enthusiasm for the crop in early 1981.

Nevertheless, the NPBRC continued screening triticale for ecological adaptability and prospective releases on a limited scale. Four new lines (T354, T355, T357 and KT02-4) were selected through the TNPT and are being proposed for release. The station also increased multiplication of the T65 and T222 seeds for commercial use due to revived interest in triticale production after the decontrol of prices and marketing of the crop in 1990. The new lines are superior to existing ones in yield, disease resistance, and grain plumpness (NPBRC, 1991).

Table 2. Mean Yield of Triticale and Wheat Varieties (Average of the Seven Sites at Locations Described Earlier over 13 Years).

Triticale		Bread wheat		Durum wheat	
Variety	Yield (kg/ha)	Variety	Yield (kg/ha)	Variety	Yield (kg/ha)
A. 1976-1980 average[a]					
T14	3830	K. Fahari	2400	Mwewe	3150
T48	3830	K. Tembo	2390	Njiwa	2460
T50	3870	Bounty	1960	KD2-6	3390
T65	4140	A. Mayo	2050		
B. 1985-1990 average[b]					
T74	2565	Mbuni	3240	Mwewe	1728
T65	3060	Kwale	2457	Njiwa	1845
T222	2916	K. Tausi	2772	Kengewa	1764

[a]Oggema *et al.*, 1981.
[b]NPBRC, 1990.

Post-Harvest Qualities of Kenya Triticales

Milling tests and baking experiments were conducted in order to assess triticale's suitability for baking purposes. Commercial milling tests were carried out in 1979 by the NPBRC in collaboration with Unga Ltd., the major triticale millers in Kenya. Flour extraction analysis was performed on 4 tons of the best grown triticales (T14, T48, T50 and T65), mixed with 4 tons of wheat. No major adjustments were made for milling the triticale grain. The following results (%) were obtained (Mulamula, 1981):

Flour extraction	75.4
Pollard extraction	17.7
Bran extraction	5.9
Milling losses	1.0
	100.0

Tests on the flour and baking characteristics were then performed on the 50%-50% mixture flour and on a 100% triticale flour at the Unga Laboratories in Nairobi. The

100% triticale flour was used to prepare non-fermented breads such as chapatis and rolls. These products had fully acceptable taste and appearance. Good quality bread with acceptable taste and volume was also produced from the 25%-75% triticale-wheat mixture (Kingma *et al.*, 1979; Wabwoto, 1981). Currently, bread from up to a 20% triticale mixture is being produced by various bakeries with suitable taste, texture, and other characteristics.

Post-harvest qualities of wheat and triticale were also analyzed by Mulamula (1981) (Table 3). Flour extraction was found to be correlated to hecto-liter weight, which in turn varies with environment. On the average, about 12% less flour compared to wheat is extracted from triticale varieties grown in Kenya.

Baking experiments were also conducted by the Department of Home Economics at Egerton University. Highly acceptable products were baked from triticale flour mixtures. The tests indicate that triticale has a strong potential in mixing with wheat for baking, especially in non-fermented products, such as chapatis, mandazis, biscuits, and the like, which require no special baking procedures and equipment. However, triticale flour has several inferior milling and baking qualities compared to wheat. To improve milling and baking qualities, both breeding research and an adjustment in the baking process and technologies used on wheat flour will be required.

Table 3. Post-Harvest Qualities of Wheat and Triticale

Characteristics	Wheat	Triticale
A. Hecto-litre weight[a]		
more than 65	68%	47%
mean	73	62
B. Flour extraction[a]		
Range	60-85%	50-69%
Mean	72%	60%
C. Flour qualities[b]		
Glutin content	higher	lower
Alpha amylase	lower	higher
Dough stand	stronger	weaker
Loaf volume	superior	inferior
Mixing tolerance	higher	slower
Fermentation time	150 minutes	shorter (105 minutes)
Yeast concentration	higher	lower

[a] Average of 13 years data on Kenya varieties (Mulamula, 1981).
[b] General, at CIMMYT laboratories (Skovmand *et al.*, 1981)

Market Organization and Pricing

Triticale varieties released by the NPBRC had shown a number of advantages over other cereals, particularly under drought stress and high soil acidity. In addition to their yield advantage over wheat under marginal conditions, the released triticales

had higher nutritive value and acceptable milling and baking qualities. This has aroused strong enthusiasm for the crop in Kenya and received considerable support from the various agricultural authorities in the country. Triticale production, however, did not take-off inspite of all the enthusiasm and arrangements made to promote the crop since the early 1980s. Poorly developed and incorrect policies were generally blamed for being the hurdle to increased adoption of triticale. Over all, triticale has encountered marketing problems in those countries which released varieties over the past three decades, i.e. Kenya, Ethiopia and Tanzania (Tanner and Mwangi, 1992).

A workshop was held at Egerton University in August 1981 to assess the potential and discuss problems of production and utilization of triticale in Kenya. The conference concluded that there is enough information to support triticale's agronomic adaptability and potential as a high quality cereal. Accordingly, it was recommended by the workshop that the Ministry of Agriculture should take urgent steps to promote the crop (Ministry of Agriculture, 1981). The major conclusion of the workshop was that appropriate marketing and price policies will play a crucial role in promoting triticale.

It has been argued that because triticale was not a scheduled crop, it suffered from lack of guaranteed market and official price, and did not qualify for short term credit (Oggema *et al.*, 1981; Mulamula, 1981; Lijoodi, 1981). Clearly, marketing and price setting were the main issues discussed during the conference and hence featured prominently in its recommendations. The workshop recommended that triticale be gazetted, so that farmers would qualify for credit, and an official price be established and a market guaranteed by the NCPB. It was also recommended that grading rules be established on the basis of various crop quality aspects, other than yield, for setting an appropriate price regime for triticale (Oggema *et al.*, 1981; Mulamula, 1981; Lijoodi, 1981).

A grading system was proposed to the triticale grading and pricing committee using hecto-liter weight and milling proportions as the basis for setting differential prices for triticale to replace the old fixed price regime. The fixed price system sets the triticale price at 85% of the wheat price on the assumption that triticale has a yield advantage of 15% over wheat, and hence will put wheat out of production if paid the same price. This price regime was adopted in order to promote triticale production in marginal areas, where it has its real yield edge, rather than competing with wheat in favorable areas. The conference concluded that this fear is unfounded as research results indicate that triticale yields are at best equal to those of wheat under favorable production environments (Ministry of Agriculture, 1981).

While triticale has never been gazetted, its price and marketing were controlled by the NCPB and private buyers were not allowed to contract directly with growers. Triticale production continued to grow at a very slow pace, perhaps even declining during the 1980s. The crop has also continued to be grown by large-scale wheat farmers who usually use most of their own production on the farm, need no credit for working capital, and have means to dispose of marketable surpluses. However, even those who continued to produce triticale did not find adequate demand and were discouraged by the NCPB's inefficient handling or reluctance to buy the crop. At the same time, end-users (millers) expressed a strong desire to increase purchases of the triticale grain by substantial proportions, but preferred to contract directly with

producers without the extra inconvenience and costs associated with using an intermediary like NCPB. Marketing of triticale was accordingly decontrolled in 1990. While it is still very early to assess impacts of liberalizing the triticale market, preliminary observations were made about a relative improvement in prices and triticale trade. The question remains, however, if a free market for triticale will work better, especially when its substitute, wheat, is gazetted and enjoys a guaranteed market at a price higher than its import parity price. Moreover, it may not help boost demand for triticale to desired levels if wheat imports continue to flow at current levels. For instance, wheat import figures for 1988, 1989 and 1990 were 76,000t, 124,000t and an estimated 267,000t respectively (GOK, 1991; DN, 1991).

Survey Methods

Data were collected from surveys of triticale farmers, seed suppliers, researchers, policy-makers, the cereals marketing board and a group of millers over two seasons. The following surveys were conducted in 1990 and 1991:

a. Informal survey of triticale farmers, end users, seed suppliers, and researchers during the 1990 season.

b. As part of a formal survey of wheat farmers, a section on triticale was included in the structured questionnaire completed during the 1990 season.

c. Informal survey of triticale growers in 1991. Complete coverage of triticale farmers was attempted during this survey to the best knowledge of local farmer organizations, extension officers, seed suppliers, millers, researchers and marketing agents, who provided the names of triticale growers.

Factual information on triticale research, production and marketing practices and policies were collected from the above listed surveys and the data analyzed to study problems of triticale production and utilization in Kenya.

Survey Results

The informal surveys of triticale growers, millers, researchers and seed suppliers in 1990 showed that triticale continues to be sown by large-scale farmers. It has been observed that triticale was produced mainly in dry areas such as Narok and on the acid soils of Uasin Gishu. When it is grown in favorable environments, triticale was found to be cultivated on the poorer fields of the wheat farm. Ten large-scale farmers were identified by various informants to have grown or bought triticale seeds in the past. Six out of the ten who could easily be traced were visited and informally interviewed on a number of triticale production aspects. The major findings of the 1990 informal survey are summarized below:

a. The variety T65 was the most commonly used triticale.

b. The majority of the surveyed farmers were found to buy from other farmers or produce their own seed after the first acquisition from KSC.

c. All farmers used the same practices on triticale as on wheat, except for less spraying of chemicals and lower fertilizer levels, on average.

d. All agreed that triticale performs much better than wheat under marginal conditions. On average, the yield advantage of triticale over wheat was estimated at 8%. Most indicated that more than 15% higher yields are obtained from triticale over wheat under severe stress (particularly low moisture regimes).

e. The majority of growers have accepted the price that is 85% of the wheat price, but complained about the difficulties associated with dealing with the National Cereals and Produce Board (NCPB). Most important among these problems are:

   i. The high handling and transportation costs due to delayed off-loading and the long wait of trucks at the NCPB depots, which led to an estimated additional cost of 5% of the crop value over and above the actual transportation.

   ii. Delayed payments for the delivered crop to NCPB.

   iii. Reluctance of the NCPB to buy the crop in the first place.

f. All the farmers liked triticale and wanted to expand if adequate demand exists.

g. On average, about 50% of the total production was fed to animals.

h. Most did not have enough contact with the research and extension agencies, and while expressing strong interest in improved triticale seeds, they were not aware of new releases or did not find the seed.

Table 4. Awareness and Problems of Triticale Production by Sample Farmers (Survey of wheat farmers in 1990, n = 97)

1.	Percent of farmers now growing triticale	2
	Area sown (ha)	50
2.	Percent produced triticale before	4
	Area sown (ha)	75
3.	Reasons for not growing triticale (% of farmers)	
	a. never heard of triticale	74
	b. low yield	2
	c. inadequate demand	14
	d. low price	4
	e. no seeds	6

To investigate farmers' awareness of triticale, a section was added to a structured questionnaire designed for a formal survey of wheat farmers in Nakuru, Narok and Uasin Gishu districts in 1990. The triticale section addressed the main issues revealed by the informal survey and that survey data are analyzed in Table 4. Only 2% of the surveyed farmers produced triticale in 1990, on a total area of 50ha. Four percent of the farmers previously grew triticale on a total area of 75ha (Table 4). The survey

showed that 74% of the farmers have never heard of triticale. Most of this group were in the small-scale class of wheat growers (85%). The majority of the farmers aware of triticale did not adopt for lack of adequate demand, unavailability of seeds and low prices (Table 4). Results of the survey indicate the significance of the extension and dissemination factor since the majority of farmers did not know about triticale.

Although another survey of triticale farmers was carried out in 1991, it was needed for the following reasons:

a. To verify and resolve the conflicting statistics on area and production of triticale.

b. To assess the effects of the major policy change that decontrolled triticale marketing in 1990 and established a free market price for the crop.

c. Generate more data on triticale production and utilization practices and problems.

A complete coverage of triticale farmers was therefore intended for this survey. Using the previous year's survey information, updated with data from other regions to complete the sampling frame, a list of triticale farmers was compiled by district (Appendix 1). Field visits were arranged with the help of extension officers and staff from the district office. Farmers were informally interviewed on various aspects of triticale production and disposition. Millers, seed suppliers and marketing agencies at the districts were also surveyed for relevant information. Results of the 1991 survey showed that 86% of the surveyed farmers previously grew triticale. In 1990, 60% of the farmers were growing triticale while 71% were growing it in 1991, possibly due to the recent change in marketing and pricing policies (Table 5).

Most of the surveyed farmers (86%) confirmed the yield advantage of triticale over wheat (Table 5). Survey results indicate that, on average, triticale yields were 12% higher than wheat. Moreover, 77% of the farmers considered triticale to be superior to wheat in terms of tolerance to diseases, particularly rust, but only 57% experienced lower production costs with triticale (Table 5). This might be because the rest of the farmers followed the same practices as wheat farmers. While most (86%) believed that they face inadequate demand for triticale, all farmers (100%) thought decontrolling triticale prices and marketing will improve demand. Only 40%, however, found the price set by the NCPB at 15% lower than wheat to be very low. The free market price of triticale was 90% of the wheat price in 1991, i.e. higher by 5% than the NCPB fixed price (85% of wheat). This indicates that decontrolling the triticale market has improved its price. The survey also found that 40% of the farmers used triticale for feeding livestock on the farm (Table 5). Amount of triticale fed to animals was estimated at 50% of total production.

Only 6% of the farmers acquired seeds from KSC for the 1991 season (Table 5). The KSC argued that it did not have the facilities to generate adequate seed supplies; therefore the company contracts with farmers to produce the required seed. The National Seed Quality Control (NSQC) then decides on certification or rejection after inspection. It has been difficult to conclude such contracts due to uncertainty about the selling price of seed. On the other hand, the company had experienced very low sales resulting in building stocks of triticale seeds in some years. This was attributed to the fact that most of the principal growers retain seeds from their own harvest. These farmers are not only self-sufficient, but also supply other farmers with seed and thus

compete with the company (Gitau, 1981). Following a decision made by the Ministry of Agriculture in the late seventies to promote triticale production, a number of farmers were scheduled to cultivate more than 200ha in 1980 in order to supply above 500 tons of seed for the 1981 season. This quantity was projected to be sufficient for growing more than 5000ha in 1981. Inspite of all the arrangements made by the Ministry, KSC could collect only 86 tons out of the total by the end of 1980; the rest was sold as grain for a price higher than what KSC had offered (Gitau, 1981). T65 is the only variety supplied by KSC.

The KSC also considered the standards required by the NSQC for triticale to be high and hence recommended lower minimum size and germination rate standards than those currently set as an equivalent to wheat (Gitau, 1981; Winkelmann, 1982).

Table 5. Results of the 1991 Survey of Triticale Sample Farmers (n = 35).

1.	% who previously grew triticale	86
2.	% produced in 1990	60
3.	% produced in 1991	71
	Total area currently sown to triticale (ha)	2400
	Average yield (ton/ha)	2.2
4.	% agree with yield advantage over wheat	86
5.	Average yield advantage as % of wheat yield	12
6.	% consider crop superior to wheat with respect to disease tolerance	77
7.	% consider cost of production lower than wheat	57
8.	% consider demand inadequate	86
9.	% think decontrol is better	100
10.	% consider NCPB price very low	40
	1990 price (Kshs./80kg): NCPB 85% of wheat price	408
	1991 price (Kshs./80kg): free market price	510
11.	% using for animal feed	40
12.	% bought seed from KSC	6

Estimating Triticale Area

Total area under triticale was estimated by Kenya Seed Company (KSC) to be 6352ha in 1982 (Gitau, 1981). The KSC's estimate was based on a total quantity of seed of 794t projected to be available by the end of 1981 from contracts and commercial production. Although KSC collected about 900 tons of seed during 1981, they had real difficulty selling these seeds to farmers and most of the crop was sold to millers. However, in another report, triticale area was estimated at about 4000 ha for the same year (Winkelmann, 1982). An even greater margin of discrepancy existed between an estimate of triticale area made by the breeding section of the NPBRC at 8000 ha (NPBRC, 1990) and other sources suggesting an area of less than 400ha of triticale for Kenya (Varughese *et al.*, 1987).

A survey conducted for this study in 1990 estimated total area under triticale to be 2500 ha. This estimate was based on the survey finding that about 3000 tons of triticale were delivered to millers in 1989. The survey also estimated the share of triticale production that goes into milling for human consumption in Kenya to be about 50%. Accordingly about 6000t of triticale in total were produced in 1989, both as animal feed

and for human consumption. At an average yield of 2.4t/ha, 2500ha were required to produce this quantity. A total of 2400ha were sown to triticale in 1991, giving an average yield of 2.2t/ha. (Table 5). Given the fact that the list of triticale farmers compiled in Appendix 1 may not be exhaustive, an 80% coverage was assumed for this survey. This suggests an estimated 3000ha total triticale area in 1991 (Table 5), generating 6600 tons of triticale grain at the average yield of 2.2 tons/ha. Approximately 50% of this quantity was used for livestock feeding and as seeds, sold or retained for the following season, which means that about 3300 tons of triticale were sold to either NCPB or millers in 1991. Because of the unwillingness of the NCPB to buy triticale or its inefficient handling and delayed payment, most farmers sold their grain to millers, mainly Unga Ltd. Unga's share was estimated at more than 80% of the sold grain. A similar amount (2500 tons) was milled by Unga in 1990. None of the farmers sold triticale to feed manufacturers. Feed manufacturing firms, on the other hand, did not think that the slightly higher nutritive value of triticale over maize would compensate for the price difference in their cost structure to stimulate demand for triticale. While triticale was sold for 85% of the wheat price set at KSh.485 per bag, maize farmers received only KSh.340 per bag in 1990.

Throughout the 1980s, Kenya had built an excess milling capacity that led to using a quota system to allocate wheat milling shares among millers. This caused a drop from 100% to about 55% utilized capacity at Unga mills by 1989. The firm had expressed strong interest in milling more triticale to raise the operating capacity, and could alone use up to 30,000t of triticale to increase milling capacity by 15%. Inadequate demand, considered by the majority of farmers as the main obstacle to expand triticale production, will consequently diminish.

Future Prospects of Triticale in Kenya

For the triticale potential to materialize in Kenya, the crop needs to be accepted by both domestic suppliers and users. On the supply side, there must be a comparative advantage over alternative crop and animal enterprises to attract producers. The proven yield advantage of triticale over other cereals under low moisture regimes, high soil acidity and disease stress is not sufficient to establish comparative advantage for the crop under marginal production environments. Production costs and output prices are important factors to consider in determining whether triticale represents the best option, in economic efficiency terms, for using the marginal land resources of Kenya. Given that production costs for wheat are higher than triticale's, it is their relative price and yield advantage that will determine which one dominates. At the average yield advantage estimated at 12% of wheat yield (Table 5), a price level lower than wheat by 12% or less would make triticale equally or more efficient than wheat under marginal environments. While attractive to producers, this price may not be acceptable to millers or bakers, given differences in the post-harvest qualities of the two cereal grains. In the case of maize, however, triticale dominates in both: higher price and better yield for marginal land farmers. Farmers' awareness and seed availability are of course crucial for triticale success. Unfortunately, our surveys have identified low awareness, especially among small-scale farmers, lack of access to seeds, and an inadequate market for triticale as the major barriers to its spread.

In spite of the strong potential of triticale in feed manufacturing due to higher nutritive value, it has been promoted mainly for human consumption in Kenya. Triticale, however, is still being produced by about 40% of the farmers mainly for

animal feed purposes on most large livestock production farms (Table 5). On the other hand, a cheaper alternative source of energy, i.e. maize grain, was a major reason behind the lack of interest in triticale by feed manufacturers. Moreover, one objective of promoting triticale was to change the belief that it was only good as animal feed and not fit for human consumption. It is also important to note that no effort or studies were carried out to ascertain the economic value of triticale as an alternative source of protein and calories for animals in Kenya. These are some of the factors that have inhibited the demand for triticale by the feed manufacturing industry.

As Kenya currently imports about 50% of its total wheat consumption, triticale is considered an option for reducing wheat demand. Milling and baking tests have shown that the post-harvest qualities of triticale, though inferior to wheat, are fully acceptable for mixing with wheat flour for bread making. Up to 20% triticale flour is currently mixed with wheat in bread making and home baking without complaints, which indicates a potential for triticale to reduce wheat imports by 40%. Unless mandated, bread made from the mixture flour would seek lower prices because of the lower quality factor. Through the derived demand for the grain, this would translate into a lower price for triticale. How much lower is the biggest challenge for policy makers under administered prices, and for the various market forces under the free regime. Variations in the characteristics of the two products make them imperfect substitutes that would not earn the same price. While triticale outyields wheat, the latter has superior milling and baking qualities. The yield advantage is attractive to producers, whereas consumers are concerned about post-harvest qualities.

A market price for triticale will be a function of its post-harvest qualities as compared to its substitutes, wheat for baking and maize for feed manufacturing, and their respective prices. Since wheat and triticale markets are closely tied together, allowing free trade in one of them will not be as effective if the price of the other remains controlled. Although triticale is decontrolled, its price will always move with the officially fixed price of wheat depending on consumers' assessment of the quality differences between the two commodities. If a price is to be chosen for triticale relative to wheat, variations in the milling and baking characteristics of the two products need to be evaluated, the most important of which is flour extraction rates. If on average, about 12% less flour compared to wheat is extracted from triticale varieties grown in Kenya, the price per unit of triticale flour will thus be 12% lower than that of wheat, given equal flour qualities (Table 3). However, demand for triticale flour as a human food may not expand if protection to domestic wheat production is removed and wheat imports are allowed, i.e. the subsidy to wheat farmers lifted. On the other hand, triticale will have to compete with flour of the sorghum variety KAT367, recently released by the Kenya Agricultural Research Institute (KARI), in mixing with wheat for bread. It has been argued that the mentioned sorghum variety gave about 25% mixture flour with high baking qualities (Daily Nation, 1992). Bearing in mind that sorghum is more adapted to marginal environments, the triticale option needs to be carefully examined with this in mind. At any rate, the potential for higher quality triticale flour is the present challenge for researchers at the NPBRC.

Conclusions and Implications for Research and Policy

Surveys of triticale farmers conducted in 1990 and 1991 have shown that the crop was mainly sown by large-scale farmers. Thirty five farmers were surveyed in 1991 and

believed to represent at least 80% of the total number of triticale growers in the country. About 70% of these farmers were growing triticale in 1991 on a total area of 2400 ha. Given the 80% coverage, this indicated that about 3000ha are sown to triticale in Kenya giving a total production of 6600t. The study found that half of this production was used for animal feed.

An awareness survey among wheat farmers in Nakuru, Narok and Uasin Gishu districts in 1990 indicated that the majority of farmers, especially among small-scale growers, were not aware of triticale and have little contact with research. This would not have been the case if extensive on-farm experimentation was adopted by researchers. It is therefore important to promote on-farm research, which, in addition to disseminating information about triticale, makes the introduced technology well suited and acceptable to farmers. More effective research-extension-farmer linkages are thus required for faster diffusion and adoption of the triticale alternative. On the other hand, farmers who are aware of or grow triticale indicated that lack of adequate demand was the major reasons for the slow growth if not decline in triticale production. Due to the unwillingness of the NCPB to buy triticale or because of its inefficiency and delayed payment, most farmers sold their grain to millers. Unga Ltd. alone bought about 80% of the 3300 tons of grains sold in 1991. None of the farmers sold triticale to feed manufacturers, mainly because cheaper alternatives, such as maize, were available to mix for animal feed.

While triticale has shown a strong potential for replacing wheat under severe stress where, on average, it yields about 12% higher, its advantages and qualities as a substitute for human consumption were not adequately established. As triticale has been promoted mainly to substitute for wheat as a human food, breeding work on improving the milling and baking qualities of triticale is required to boost demand. This will of course entail allocating more resources to triticale breeding and on-farm research programs. Research into adjusted baking technologies that would contribute to improved dough and bread qualities is also required together with wider consumer acceptance tests and surveys.

Millers, however, expressed a strong desire to increase purchases of the triticale grain by substantial proportions, but preferred to contract directly with producers without the inconveniences of using an intermediary like NCPB. This is mainly because Kenya has built excess milling capacity during the eighties leading to a significant drop in utilized capacity. Major milling firms such as Unga Ltd., which is currently operating at 55% capacity, indicated interest in mixing more triticale to raise their operating capacity to economic levels consequently diminishing inadequate demand.

In addition to lack of awareness and insufficient demand, unavailability of seeds was found to be another important barrier to increased triticale production. Therefore, KSC will need to allocate more resources to multiplication of sufficient supplies of triticale seeds and diversify its varietal selection to types other than T65. Research could also contribute to alleviating shortages of seed in the short-run by undertaking more seed multiplication. Adjustments in seed certification standards may be required to establish lower size and germination rate requirements for triticale than those of wheat in order to increase the share of seed accepted from farmers' production contracted by the seed company. Demand for seed, however, is derived from the final demand for triticale, and hence is highly influenced by movements in the grain price and marketing arrangements.

On the other hand, the triticale option needs to be evaluated against other alternatives such as mixing of sorghum flour for bread making. Moreover, as the triticale price is closely tied to wheat, the producer's subsidy built into the official price of wheat, which is currently set at 1.4 times its import parity price, is transferred to the triticale market. This indicates that triticale may not represent the best alternative for using the marginal land resources of Kenya in economic efficiency terms, especially if the wheat price subsidy is lifted. The comparative advantage of triticale, therefore, needs to be carefully examined against other options.

The fact that the yield advantage over wheat alone was not sufficient for triticale to take off during the past decade indicates the importance of the demand factor and the policy environment. While decontrolling the triticale market may stimulate high demand, it may not reveal the true economic potential of triticale if distortions in its close substitutes markets, such as wheat, continue to exist. As wheat marketing and price are controlled, the price of triticale will remain effectively set to move in proportion to wheat. At the same time, allowing importation of wheat at the existing domestic price level implies a substantial profit margin of about 40% for wheat importers and thus a higher incentive to over-import wheat into the country as in 1991. This in turn works against increased demand for wheat substitutes such as triticale. On the other hand, decontrolling the wheat market will lead to lower prices and profitability and hence reduced willingness on the part of farmers to produce the crop, inspite of the positive impact of lower price on demand. However, post-harvest qualities and consumer acceptance of triticale compared to wheat will provide the basis for establishing a relative triticale to wheat price under free trade.

Although about 50% of the triticale produced in Kenya was used to feed animals, the nutritive value of the common triticales and their potential for livestock feeding were not investigated and the crop was promoted mainly for human consumption. A study of the economic value of triticale as a substitute to other cereals as animal feed is thus required.

Appendix 1. Triticale Farmers Surveyed in 1991.

FARM		DISTRICT
1.	Manera Farm (Delamere)	Nakuru
2.	Soy Sambu Estate (Delamere)	"
3.	Menengai Feedlots (G. NightNgale)	"
4.	Nunjoro Farm Ltd. (C. NightNgale)	"
5.	Kenana Farm Ltd. (B. NightNgale)	"
6.	Madrugada Farm (P. Barclay)	"
7.	Ngogongeri Farm (Egerton)	"
8.	Rift Valley Institute of Science andTechnology farm	"
9.	Mr. W.K.A. Kikwai (Rongai)	"
10.	Mr. David Nganga (Mai Mahiu)	"
11.	Kinoru Farm (Bahati)	"
12.	National Plant Breeding Research Center	"
13.	Kijabe Ltd. (Ndabibi-Higgins)	Narok
14.	Shimo Ltd. (Neylan)	"
15.	Endebess Estates	"
16.	Gill	"
17.	Hugowoods	"
18.	Dakaine Ltd.	"
19.	Oleria Ltd.	"
20.	Guy Dollier	"
21.	Karanja Estate Ltd.	"
22.	East Africa Tanning Extract Co. Ltd.	Uasin Gishu
23.	Chemweno Farm	"
24.	Maji Mingi Estates	"
25.	J.E. Kruegar	"
26.	Jagir Singh	"
27.	El-Farm (Hon. Biwott)	"
28.	Hon Chesire	"
29.	Dr. Kiritu	Laikipia
30.	Laikipia Ranch	"
31.	Laikipia campus	"
32.	Wangu Embori	Timau
33.	Gatigiti Farm	"
34.	Musila Farm	"
35.	Moran Ltd. (Kirumba Mwaura)	Kajiado

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